NEW TRILOBITES FROM THE SILURIAN OF NORTH-EAST GREENLAND, WITH A NOTE ON TRILOBITE FAUNAS IN PURE LIMESTONES

by P. D. LANE

ABSTRACT. A trilobite fauna of approximately Wenlock age from Kronprins Christians Land, north-east Greenland is described. The fauna occurs in a pure limestone and includes five new species of trilobites—*Opoa adamsi* gen. et sp. nov., *Meroperix ataphrus* gen. et sp. nov. (Scutelluidae); *Selenoharpes loma* sp. nov. (Harpidae); *Chiozoon cowiei* gen. et sp. nov., *Hyrokybe pharanx* gen. et sp. nov. (Cheiruridae); with goldillaenids (two types) and lichids (two types) which also probably represent new genera, but which are not named because of the small number of specimens known. Members of the Calymenidae, Odontopleuridae, Proetidae, Otarionidae, and Illaenidae also occur. Comparison of elements of this new fauna with Silurian trilobites already described is possible only in three cases, the harpid being similar to several Silurian members of the genus, *Chiozoon* having a representative species in the Upper Silurian of Tadzhikskaya, USSR, and *Hyrokybe* with a possible species from the Lower Devonian of the western Urals. The delimitation of the Scutelluidae and the position of the Goldillaeninae is discussed. The occurrence of the same trilobite families, or of different trilobite families with similar morphology, in pure limestones differing in age from Arenig to middle Devonian is noted.

THE material upon which this paper is based was loaned to the author by Dr. J. W. Cowie and Dr. P. J. Adams, who made the collections on a Danish state-aided expedition led by Lauge Koch.

As the best map of the area available when the fossils were collected was to a scale of 1:1,000,000, the locality information is not precise, but for practical purposes may be generalized as follows—'2 kilometres from the north shore of Centrumsø, at a height of about 300 metres, at approximately 22° 20′ W, 80° 13′ N, in Kronprins Christians Land, west of Dijmphna Sund, north-east Greenland.'

The fossils come from a sequence of dolomites, limestones and shales, and were collected through a thickness of a little over 300 m of rock (text-fig. 1). All the fossils described here are in a pure limestone matrix preserved as calcified exoskeletons, though this has been removed sometimes during preparation. Localities 1418–23 are in boulders at the base of the Profilfjeldet Shales, these boulders having the lithology of the underlying Drommebjerg Limestone (Cowie 1961, p. 164) at the top of which limestone, locality 1510 is situated. Locality 1511 is in the Centrum Limestone and Dolomite (Adams and Cowie 1953, p. 12) about 100 m below the base of the Drommebjerg Limestone.

Graptolites collected 50 m above the base of the Profilfjeldet Shales were identified by Dr. I. Strachan of Birmingham University as *Monograptus*? *flemingii* (Salter) and *Cyrtograptus* ex gr. *rigidus* Tullb. indicating an Upper Wenlock age. Brachiopods from the same beds as the trilobites described here also indicate a Wenlock age and though this dating cannot be refined from the present study of the trilobite fauna, such an age is in agreement with the evidence provided by these species.

The high percentage of new taxa in this trilobite fauna can be explained by its occurrence in pure limestone, since no faunas in a comparable matrix (and therefore presumably from a similar environment) have been described from the middle Silurian.

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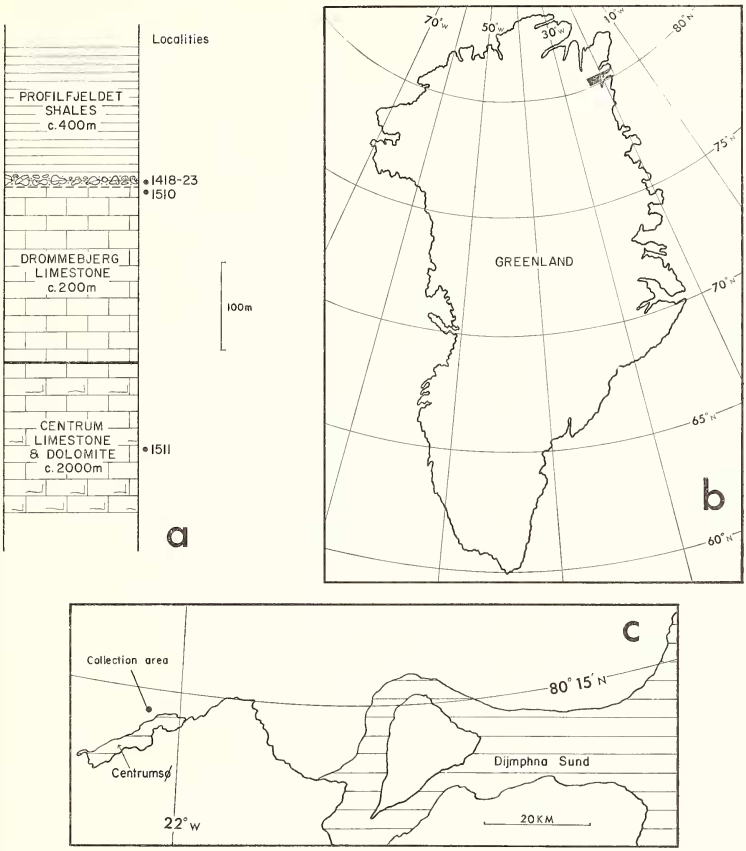


TEXT-FIG. 1. *a*, Generalized stratigraphical succession, with horizon of localities indicated. *b*, Map of Greenland with area of enlarged sketch map shaded. *c*, Sketch map of part of Kronprins Christians Land with the approximate area in which the collections were made indicated.

The general similarity of this fauna to those in Ordovician and Devonian rocks of similar facies is discussed below.

Scattered through the fossil record from the Llanvirn to the Middle Devonian, algal-bryozoan-coral-trilobite-brachiopod faunas occurring in pure white limestone are to be found. These limestones resemble one another because they are of similar facies, and they often contain masses of sparry, bioclastic limestone, which sometimes yield a great predominance of a single species or type of fossil; in some of these sparry masses, trilobite exoskeletons are the only fossil remains to be found.

The trilobite faunas preserved in these rocks are remarkable in that representatives of the same trilobite families commonly occur during an absolute time range of about 120 m.y. For example, cheirurids and harpids are present in rocks of such facies over the whole of the time span indicated. In some cases the use of the family taxon for such comparisons gives only a general guide, for some trilobite families died out during this time range, to be replaced in the faunas by others having a similar gross morphology. These similarly constructed trilobites presumably occupied the same or similar ecological niches. To take an example of this, members of the Illaenidae are predominant, and nileids and asaphids common in Middle Ordovician examples of the facies-fauna. The Nileidae and Asaphidae, however, died out before the end of the Ordovician. Illaenids are also common in the Silurian examples of such faunas, but they also died out before the end of that geological period. But the place in the faunas left by the extinction of these trilobites with broad convex, relatively smooth exoskeletons, became occupied by other trilobites of a similar gross morphology, notably the scutelluids. Members of this family are present in the earliest Ordovician white limestone faunas (e.g. *Perischoclonus* in the Lower Head fauna of Newfoundland), but are not important, numerically. In the Ashgill reefs of Dalarna, Sweden, scutelluids have become much more important following the extinction of the nileids and asaphids, there being vast numbers of a species of a single scutelluid genus—*Eobronteus*—present, along with illaenids which are still predominant in the fauna. With the decrease and then demise of the illaenids in Silurian times a rapid radiation of scutelluid genera took place from the stocks already present.

For the purpose, therefore, of comparing the faunas of these widely stratigraphically separated rocks, those forms with smooth, broad, exoskeletons are combined and used as a unit (illaenids, scutelluids, asaphids and nileids).

Figures of actual abundance of parts of the exoskeleton of the various species present are available only for the Ordovician Lower Head fauna of Newfoundland (Whittington 1963, p. 12) and for the small fauna described here (see Table 1). These faunas are widely separated in time and make a general comparison interesting.

In the Lower Head fauna, the illaenid exoskeletons alone comprise 30% of the preserved trilobite remains. Cheirurids account for 20% and harpids 3% of the fauna, and there are very small numbers of scutelluids and nileids. Other significantly represented families are the bathyurids and lichids which each comprise 15% of the fauna. Of the approximately 130 trilobite fragments in the Silurian fauna described below, the smooth forms (predominantly scutelluids with a few illaenids) comprise 33%, Cheiruridae account for 32%, and Harpidae 17% of the fauna.

Comparisons with other examples of white limestone facies-faunas must be subjective in the absence of absolute numbers of various trilobite species. However, the Swedish and British Ashgill examples (Boda Limestone of Dalarna, Keisley and Chair

of Kildare Limestones of Northern England and Eire respectively) are dominated numerically by the illaenids, scutelluids, harpids, cheirurids and lichids. The Niagaran reefs of the Great Lakes area have a trilobite fauna in which the families Cheiruridae, Lichidae and Odontopleuridae, along with the smooth forms (illaenids and scutelluids) predominate. Again, the Lower Devonian Konĕprusy Limestone of Czechoslovakia has mainly scutelluids, harpids, cheirurids and proetids, and the English South Devon middle Devonian limestones yield predominantly members of the Scutelluidae, Cheiruridae and Harpidae.

TABLE 1

	Cephala	*Cranidia*	*Free cheeks*	*Hypostomes*	*Thoracic segments*	*Pygidia*
Opoa adamsi gen. et sp. nov.	—	7	—	—	—	10
Meroperix ataphrus gen. et sp. nov.	—	8	1	1	1	5
Goldillaenid gen. et sp. indet. 1.	—	2	1	—	—	—
Goldillaenid gen. et sp. indet. 2.	—	1	1	—	—	3
Stenopareia sp.	1	4	—	—	—	—
Cyphoproetus sp.	—	1	—	—	—	—
Warburgella sp.	1	1	2	—	—	?2
Otarion sp.	—	2	1	—	—	—
Scharyia sp.	—	?1	—	—	—	1
Selenoharpes loma sp. nov.	20			1	—	—
Chiozoon cowiei gen. et sp. nov.	1	14	—	4	8	8
Hyrokybe pharanx gen. et sp. nov.	2	4	—	—	—	—
Calymene sp.	2	2	—	—	—	—
Dicranopeltis? sp.	1	1 (?2)	—	—	—	—
Ceratocephala? sp.	—	—	1	—	—	—

Other calcareous sequences contain faunas of trilobites which are, in large part, similar to those of the white limestones considered above. For example, the trilobite fauna of the Table Head Formation of Newfoundland, which is a sequence of mainly well bedded, impure limestones, has 36% of smooth forms (Illaenidae, Asaphidae, Nileidae and Scutelluidae), 5% of Bathyuridae, and only very small percentages of cheirurids and harpids. The high percentage of the smooth forms might indicate the proximity of a reef environment from which these exoskeletons were derived.

In the pure limestone environment the individual niches occupied, or the separate roles played by the members of these constantly present trilobite families or types is not known. But the dangers and difficulties of applying faunal indexes, except at the specific level, as support for contemporaneity between faunas is highlighted. It is apparent from the above examples that a greater similarity of trilobite faunas might be expected in pure limestone rocks of different ages, than in rocks of different facies but of the same age.

SYSTEMATIC PALAEONTOLOGY

All the material upon which this paper is based is housed in the Mineralogisk Museum in Copenhagen, Denmark. Register numbers are prefixed 'MMH' and are only allotted to figured specimens.

Family SCUTELLUIDAE Richter and Richter 1955

Note. There has been much discussion about the correct family group name to be used for the group of trilobites similar to *Scutellum* Pusch 1833. The present author is in agreement with the views of

Erben and Whittington (1967, p. 230) who argue on several grounds for the retention of the generally accepted name Scutellidae in its amended spelling Scutelluidae.

Discussion. The composition and delimitation of the family Scutelluidae has changed markedly in recent years. Richter (*in* Moore 1959, p. O367) considered the family 'Thysanopeltidae' to contain only *Scutellum* Pusch 1833 (with six subgenera), *Eobronteus* Reed 1928, *Weberopeltis* Maksimova 1957 and *Octobronteus* Weber 1945. Šnajdr 1958 added his new genera *Kosovopeltis*, *Decoroscutellum*. *Bojoscutellum*, *Platyscutellum* and *Poroscutellum* to the family. The same author in 1960 considered the six subgenera of *Scutellum* to be of generic rank (*Paralejurus* and *Thysanopeltis* Hawle and Corda 1847; *Planiscutellum* and *Scabriscutellum* Richter and Richter 1956; *Kolihapeltis* Prantl and Přibyl 1947), agreed *Eobronteus* and *Octobronteus* belonged to the family and added a further seven genera and one subgenus (*Protobronteus*, *Protoscutellum*, *Microscutellum*, *Cornuscutellum*, *Spiniscutellum*, *Breviscutellum*, *Metascutellum* and *Decoroscutellum* (*Flexiscutellum*)). At that time Šnajdr was apparently unaware of the existence of *Weberopeltis*. Balashova (1959, p. 36) recognized the difficulty of delimiting the Styginidae from the Scutelluidae, and though preferring to retain the former family as had Whittington (*in* Moore 1959, p. O365), she removed *Bronteopsis* Nicholson and Etheridge 1879 from it and placed this genus in the Scutelluidae. In addition Balashova at the same time erected within the Scutelluidae the new subfamily Goldillaeninae with *Goldillaenus* as type (this genus had formerly been regarded as an illaenid), and included her new genus *Goldillaenoides*. Jaanusson (*in* Moore 1959, p. O374) retained *Goldillaenus* Schindewolf 1924 as a subgenus of *Illaenoides* Weller 1907 within the Bumastinae (Illaenidae).

Whittington (1963, p. 83) reappraised the family Scutelluidae and stated that he preferred to merge with it the Styginidae; *Stygina* Salter 1853, *Bronteopsis*, *Eobronteus*, *Protobronteus* and *Perischoclonus* Raymond 1925 he considered to be early members of the Scutelluidae.

Here, the preference of Whittington to merge the Styginidae with the Scutelluidae is accepted, as is the assignment by Balashova of the Goldillaeninae to the family, though further discussion of this group will be found below under the relevant subfamily heading. The monotypic Theamataspidinae Hupé 1953 should also be merged with the Scutelluidae as the single specimen upon which the monotypic genus is based is an immature cranidium not unlike immature specimens of species of the genus *Raymondaspis* Přibyl 1949; the small pygidium doubtfully referred to *Theamataspis* (Öpik 1937, p. 40, pl. 4, fig. 8) might be scutelluid in nature.

Subfamily SCUTELLUINAE Richter and Richter 1955

Genus OPOA gen. nov.

Type species. Opoa adamsi sp. nov.

Derivation of name. ope (Gr.) = hole+*oa* (Gr.) = border. Gender feminine.

Diagnosis. Posterior part (approximately half) of glabella subparallel-sided, anterior part expanding rapidly forward, with four pairs of muscle impressions adjacent to axial furrow. Occipital impression large, 1g and 2g confluent, 3g smaller and placed close to 2g (for muscle impression terminology see Šnajdr 1960, text-fig. 2); frontal lobe with anterior median depression which impresses very weak preglabellar furrow

and anterior border. Palpebral lobe forming highest point of cranidium, anterior margin opposite posterior of basal glabellar lobes, posterior margin opposite mid length of occipital ring. Posterior part of fixed cheek very narrow (exs.), vertical, forming widest part of cranidium; lateral muscle impression crescentic, placed adjacent to axial furrow and reaching from opposite anterior of occipital muscle impression to posterior of 1g. Pygidium with inflated axis about one fifth sagittal length of whole; seven pairs of pleural ribs separated by distinct furrows, these becoming indistinct near the margin; median posterior rib wide, bifid over posterior half of length. Posterolateral margin of pygidium 'scalloped'. Doublure with subparallel raised lines distally, less regular and parallel proximally, in the sagittal line the doublure just more than half the length of the pygidium. Dorsal surface of cranidium and pygidium with large irregularly spaced tubercles and between them a honeycomb sculpture.

Discussion. This new genus can be distinguished from all other members of the Scutelluidae by the arrangement of the glabellar muscle impressions, 1g and 2g being confluent, the 3g very close to these and all three placed adjacent to the axial furrow. In addition the anterior medial pit does not occur in any other scutelluid genus in which muscle impressions are well developed, and the honeycomb sculpture of the exoskeleton of *Opoa* has not been described in any other scutelluid. These differences allow *Opoa* to be readily separated from all other genera of the Scutelluidae.

Opoa adamsi gen. et sp. nov.

Plate 59, figs. 1–10

Derivation of name. In recognition of one of the collectors of this fauna, Dr. P. J. Adams.

Holotype. MMH 11317 (Pl. 59, figs. 1*a–d*) cranidium; loc 1419. Length (sag.) 15·5 mm; width (tr.) anteriorly 16·0 mm (est.); width (tr.) posteriorly 19·5 mm (est.).

Other figured material. Loc. 1418–MMH 11326 (pygidium); Loc. 1419–MMH 11318–20, 11325 (cranidia); Loc. 1421–MMH 11323 (pygidium); Loc. 1510–MMH 11321, 11324 (pygidia); Loc. 1511–MMH 11322 (pygidium).

Additional material. Loc. 1418–1 cranidium, 1 pygidium; Loc. 1419–1 pygidium; Loc. 1421–1 cranidium.

Description. Glabella convex, posterior part (about half) approximately parallel sided, anterior part expanding rapidly foward to reach a maximum width (tr.) close to anterior margin where it is about twice as wide as posteriorly. Occipital ring convex, wide medially where it slopes gently forward to occipital furrow which is narrow here, and bears an irregular honeycomb sculpture (raised ridges enclosing depressions): laterally occipital furrow wider and smooth at occipital muscle impression. Width of glabella across basal lateral lobe nearly as great as that of occipital ring (tr.); anterior to this glabella narrows a little before rapidly expanding. Basal and median lateral glabellar muscle impressions (1g and 2g) smooth, confluent, placed anterior to basal glabellar lobe and adjacent to axial furrow; anterior lateral muscle impression (3g) smaller than combined 1g and 2g from which it is only just separated (Pl. 59, fig. 1a). Glabella everywhere with large irregularly spaced tubercles between which the honeycomb sculpture is present. To the anterior of the frontal lobe a shallow pit-like depression is situated which also affects the preglabellar furrow and anterior border; anterior border very narrow sagittally and laterally, preglabellar furrow narrow, widening a little abaxially.

Fixed cheek convex anteriorly, strongly convex posteriorly with surface sculpture like that of glabella. Palpebral lobe extending from opposite posterior of basal glabellar lobe to opposite mid length of occipital ring, forming highest point of cranidium. Lateral muscle impression cresentic in outline, adjacent to axial furrow, with glabellar muscle impressions forming a continuous area, which obscures

the nature of the axial furrow. Anterior branch of facial suture running subparallel to axial furrow until opposite 3g where it runs nearly exsagittally to approach lateral part of frontal lobe; posterior branch runs strongly downwards due to convexity of cheek here, then parallel to posterior margin of cranidium before cutting this latter at a point further from the sagittal line than widest point of frontal part of fixed cheek. Because of convexity of cranidium, narrow posterior part of cheek vertical. Doublure bent down at an angle of about 120° to forward slope of frontal lobe, curved in lateral and transverse profiles, narrow laterally but quickly widening to maximum width; it bears fine raised ridges subparallel to anterior margin, but no surface sculpture like that of dorsal surface of cranidium.

Pygidium elliptical, a little wider than long (sag.), with axis extending about one fifth sagittal length, this axis inflated and showing a faint trilobation in variation in the sculpture, the central lobe having large closely packed tubercles but laterally there being a distinct line beyond which there are only one or two lines of tubercles; anterior width of axis (tr.) as great as sagittal length. Axial furrow distinct. Pleural regions adaxially flat laterally, a little concave posteriorly; abaxially pleural regions curve down though the outer part (about half) is again slightly concave dorsally. Seven pairs of pleural ribs laterally (Pl. 59, fig. 5); median pleural rib wide anteriorly widening posteriorly and bifid for posterior one third to one half of its length. Between ribs are distinct furrows which themselves first widen and deepen, then shallow towards margin which, like the ribs, they meet as less distinct features. Where each pleural rib reaches margin, an outwardly concave feature is formed which causes the pygidial margin to have a 'scalloped' outline (Pl. 59, fig. 5). Pleural ribs with large tubercles and dorsal surface everywhere (except in axial furrow which is smooth) with the honeycomb sculpture as seen on the cranidium. Doublure broad, reaching just over half distance from posterior margin, with indistinct ribs and furrows mirroring those on the dorsal surface of the exoskeleton, and bearing fine raised ridges (Pl. 59, fig. 7a).

Discussion. Although the cranidium of *Opoa* is different from other described scutelluid genera, the pygidium resembles that described as '*Scutellum*' *multiverrucatum* Šnajdr, 1960 (pp. 202, 262, pl. 35, figs. 1–4) from the Lower Devonian of Czechoslovakia. The pygidium of *Opoa adamsi* differs from Šnajdr's species in having a relatively longer axis, a doublure which reaches only half way forward from the posterior margin (it is relatively half as long again in '*S.*' *multiverrucatum*), and in having the honeycomb sculpture of the dorsal exoskeleton. These differences may yet prove to be specific. The cranidium figured as '*S.*' *multiverrucatum* (Šnajdr 1960, pl. 35, fig. 5) bears no resemblance to that of *O. adamsi* but is from a different horizon from the pygidia figured, and probably does not belong to Šnajdr's species.

EXPLANATION OF PLATE 59

Opoa adamsi gen. et sp. nov.

Fig. 1*a–d*. MMH 11317, holotype cranidium, loc. 1419. *a*, dorsal view, ×3; *b*, oblique anterolateral view showing anterior doublure and high palpebral lobe, ×3; *c*, oblique posterior view showing narrow posterior part of fixed cheek, ×3; *d*, dorsal view showing muscle impressions lying along axial furrow, and 'honeycomb' surface sculpture, ×6.

Fig. 2. MMH 11318, small cranidium, dorsal view, loc. 1419, ×5.

Fig. 3. MMH 11319, cranidium, dorsal view, loc. 1419, ×3.

Fig. 4*a–b*. MMH 11320, cranidium, loc. 1419, ×3. *a*, dorsal, and *b*, oblique lateral views.

Fig. 5. MMH 11321, pygidium, dorsal view, loc. 1510, ×3.

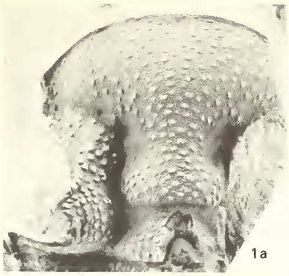
Fig. 6. MMH 11322, pygidium, dorsal view, loc. 1511, ×2.

Fig. 7*a–b*. MMH 11323, pygidium, loc. 1421, ×2. *a*, dorsal, and *b*, lateral views, showing extent of doublure and strongly raised axis.

Fig. 8*a–b*. MMH 11324, pygidium, loc, 1510, ×1·5. *a*, dorsal, and *b*, lateral views.

Fig. 9. MMH 11325, cranidium, dorsal view, loc. 1419, ×3.

Fig. 10. MMH 11326, pygidium, dorsal view, loc. 1418, ×1·5.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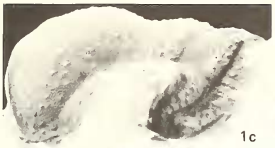
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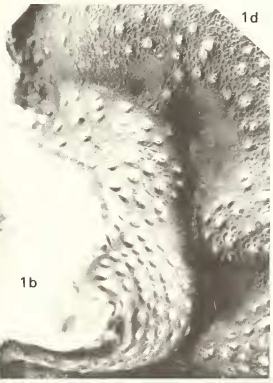
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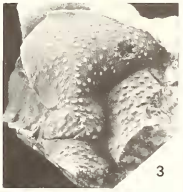
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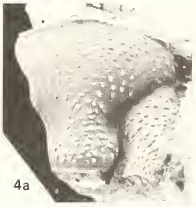
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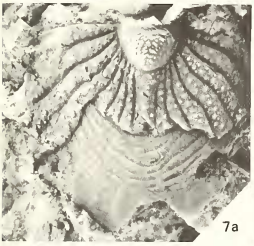
4b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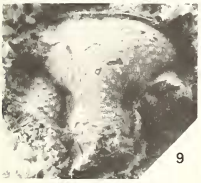
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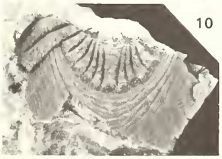
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8b

LANE, Silurian trilobites

Genus MEROPERIX gen. nov.

Type species. Meroperix ataphrus sp. nov.

Derivation of name. meros (Gr.) = side+*perix* (Gr.) = trench.

Diagnosis. Glabella narrowing forward over posterior part (about half), anteriorly expanding rapidly forward; 1g placed at anterior of posterior part of glabella. Palpebral lobe opposite, and of about the same extent (exs.) as basal glabellar lobe. Posterior part of fixed cheek very narrow (exs.), its dorsal surface inclined backward. Anterior border and preglabellar furrow laterally distinct and very narrow, not present over medial three fifths of frontal lobe. Pygidium of low convexity, axis about twice as wide (tr.) as long (sag.), occupying about one fifth of sagittal length of whole. Seven pairs of weakly convex pleural ribs, and a posterior median rib which is wholly divided in large holaspides, the posterior three fifths divided in smaller specimens.

Discussion. The shape of the glabella, contracting in transverse width forward from the occipital ring, and then expanding very rapidly, and the lack of a preglabellar furrow and anterior border medially, serve to distinguish *Meroperix* from other scutelluids. The position of the cranidial muscle impressions is also characteristic, with 1g and 2g placed adjacent to, and 3g a little way from, the axial furrow. *Meroperix* does not closely resemble any described scutelluid.

Meroperix ataphrus gen. et sp. nov.

Plate 60, figs. 1–12

Derivation of name. Contraction of *ana* (Gr.) = without+*taphrus* (Gr.) = furrow.

Holotype. MMH 11327 (Pl. 60, figs. 1*a–c*) cranidium, loc. 1421. Length (sag.) 12·8 mm; width (tr.) anteriorly 16·0 mm (est.); width (tr.) posteriorly 15·0 mm (est.).

Other figured material. Loc. 1418–MMH 11329 (free cheek), 11330 (pygidium); Loc. 1421–MMH 11328 (cranidium), 11338 (thoracic segment), 11337 (pygidium); Loc. 1422–MMH 11336 (pygidium); Loc. 1423–MMH 11334 (cranidium); Loc. 1510–MMH 11333 (cranidium), 11335 (hypostome), 11332 (pygidium); Loc. 1511–MMH 11331 (pygidium).

Additional material. Loc. 1420–1 cranidium; Loc. 1421–1 cranidium; Loc. 1510–2 cranidia.

Description. Glabella gently convex, posterior part narrowing forward, anterior part widening rapidly in the same direction, elliptical in front, laterally delimited by a shallow axial furrow. Occipital ring convex, narrowing (tr.) forward; occipital furrow narrow and shallow mesially, widening (exs.) a little laterally where the occipital muscle impression is situated. Anterior to occipital furrow, remainder of posterior part of glabella narrows forward a little and has low transverse and sagittal convexity. Anterior part of glabella increasing in width markedly forward, with increased transverse and sagittal convexity; widest point of glabella twice as wide as narrowest point (see Pl. 60, fig. 1*a*). 1g lunate, placed on anterior of narrow part of glabella adjacent to axial furrow and reaching one third way across, exsagittally about as long as basal glabellar lobe; 2g a small ovate impression immediately anterior to this; 3g placed at a small distance from the axial furrow opposite a slight arching outward of the anterior part of the axial furrow, oval in shape. Narrow convex anterior border and very narrow preglabellar furrow present laterally, both indistinct over medial three-fifths of frontal lobe: their position is indicated by upper terrace line of doublure, which is continuous across, whilst some of the terrace lines of the anterior part of the frontal lobe are terminated by it (Pl. 60, fig. 1*c*). Doublure of cranidium wide sagittally but narrow laterally, convex (tr. and sag.), bearing fine furrows and low, wider convex ribs. Glabella, except on muscle impressions and occipital region, with similar furrows and ribs subparallel to the anterior margin and occasionally anastomosing. Occipital ring with fine

raised ridges parallel to those of the rest of the glabella, and a tubercle on the sagittal line placed nearer the posterior than the anterior margin.

Fixed cheek of low convexity; palpebral lobe opposite, and of about the same extent as the basal lobe not as high as the sagittal line of the glabella. Lateral muscle impression lunate, adjacent to axial furrow (Pl. 60, fig. 1*a*). Anterior branch of facial suture straight, running toward axial furrow; posterior branch curves first down a little, then outward, finally cutting the posterior margin at about the same distance from the mid line that the anterior branch cuts the anterior margin. Small, narrow (exs.) posterior section of fixed cheek tilted backward a little, bearing transverse posterior border furrow, posterior border widening a little abaxially. Fixed cheek everywhere except on posterior border and posterior border furrow with fine anastomosing raised ridges.

Free cheek attributed to this species (Pl. 60, fig. 3) dominated by a large, inflated visual surface which bears about 35 files of lenses, 15 lenses high at the maximum. Lateral border narrow, convex, with fine, very closely spaced terrace lines; over convex surface of fixed cheek abaxial to the visual surface, subparallel terrace lines are situated, disposed subparallel to the lateral margin of the free cheek, and much more widely spaced than on the lateral border; these lines curving outward at inner margin of wide, shallow lateral border furrow to run near the exsagittal direction, and dying out before reaching the lateral border. Doublure convex, with terrace lines subparallel to those on the lateral border furrow above, most distinct at the margin, dying out inward. Genal angle not preserved.

Hypostome trapezoidal in outline, widest across anterior wings. Middle body narrowing backward; anterior lobe convex (tr. and sag.), about 2/3 sagittal length of whole, and bearing a few fine terrace lines placed so as to be subparallel to the margin of the middle body. Maculae pronounced oblique convex bosses, elongated in a line at about 30° to transverse direction, smooth, approaching 1/3 width of middle body at that point. Posterior lobe of middle body short (sag.), almost plane, indistinctly delimited from the posterior border behind. Anterior margin a smooth curve; no anterior border adjacent to middle body. In ventral view the lateral border is wide just posterior to the anterior wing, rapidly narrowing back and retaining this width round the posterior of the middle body as the posterior border; posterolaterally the border is greatly extended in a dorsal direction. Borders everywhere

EXPLANATION OF PLATE 60

Meroperix ataphrus gen. et sp. nov.

Fig. 1*a–c*. MMH 11327, holotype cranidium, loc. 1421, ×3. *a*, dorsal view; *b*, lateral view showing even curve from glabella to doublure in sagittal line; *c*, oblique anterolateral view showing anterior border furrow only developed laterally.

Fig. 2. MMH 11328, small cranidium, dorsal view, loc. 1421, ×5.

Fig. 3. MMH 11329, small free cheek, dorsal view, loc. 1418, ×10, showing strong terrace lines on dorsal and outer doublural surfaces.

Fig. 4*a–b*. MMH 11330, pygidium, loc. 1418. *a*, dorsal view, ×3; *b*, dorsal view showing terrace lines interrupted on axis by smooth oval areas, ×11.

Fig. 5. MMH 11331, pygidium, dorsal view, loc. 1511, ×2.

Fig. 6*a–b*. MMH 11332, pygidium, loc. 1510. *a*, dorsal view showing paired smooth areas on axis, ×10; *b*, dorsal view, ×3.

Fig. 7. MMH 11333, cranidium, dorsal view, loc. 1510, ×4.

Fig. 8. MMH 11334, cranidium, dorsal view, loc. 1423, ×5.

Fig. 9. MMH 11335, hypostome, ventral view, loc. 1510, ×7.

Fig. 10. MMH 11336, fragmentary pygidium, dorsal view, loc. 1422, ×3, showing pathological condition of median pleural rib.

Fig. 11. MMH 11337, small pygidium, dorsal view, loc. 1421, ×5.

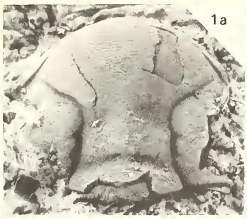
Fig. 12. MMH 11338, thoracic segment, dorsal view, loc. 1421, ×3.

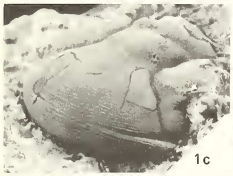
Goldillaenid *gen.* et *sp. indet.* 1.

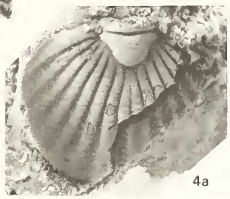
Fig. 13 MMH 11339, free cheek, dorsal view, loc. 1419, ×5.

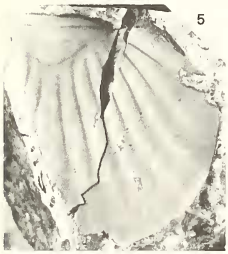
Fig. 14*a–b*. MMH 11340, fragmentary cranidium, loc. 1510, ×3. *a*, occipital and *b*, right anterior oblique views.

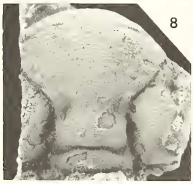
Fig. 15*a–b*. MMH 11341, fragmentary cranidium, loc. 1510, ×3. *a*, occipital and *b*, left anterior oblique views.

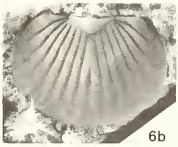


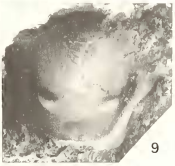


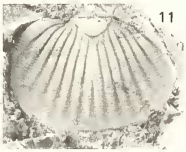


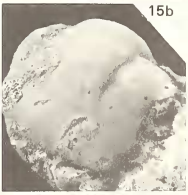












LANE, Silurian trilobites

with closely spaced subparallel terrace lines. Border furrows indistinct except adjacent to the anterior wing; posterior border furrow wide.

Thorax known from a single almost complete segment. Axial ring about one third the width (tr.) of whole segment, wider (tr.) at its posterior margin, with fine subparallel terrace lines curved concave backward. Articulating half ring narrow (sag.) tapering laterally, and bearing fine parallel terrace lines like those on axial ring. Axial furrow distinct. Pleural portion less convex (tr.) curved back, with terrace lines running a little obliquely out from exsagittal direction forward, and increasingly so laterally (Pl. 60, fig. 12).

Pygidium with ratio of width to length in large specimens 3:2, in smaller ones 4:3. Axis triangular, about twice as wide as long (including articulating half ring), of low convexity, occupying about one fifth the sagittal length of the whole; astride the sagittal line, pygidial axis bears a pair of smooth ovate areas across which the terrace lines do not run. In small specimens these smooth areas are placed relatively a little nearer the posterior margin of the axis (see Pl. 60, figs. 4*b*, 6*a*). Pleural regions almost flat but with a slight convexity about half way from margin to axis. Seven pairs of lateral pleural ribs, all with slight transverse convexity and with narrow shallow furrows between, both dying out as distinct features two thirds way to margin, though almost reaching it as indistinct features: median pleural rib wide, divided for its whole length in large specimens, for about three quarters of its length in small ones. Surface of pygidium dorsally with fine anastomosing ridges subparallel to the posterior margin, except adjacent to the lateral margin where they turn sharply backward, and on the axis where the anastomosing ridges are curved in the opposite direction. Doublure occupying at least half the sagittal length, with ribs and furrows mirroring those of the pleural regions of the dorsal surface of the pygidium, and with fine subparallel ridges curving concave backward on the ribs, and convex backward in the furrows.

Discussion. Of described scutelluids, *Meroperix ataphrus* resembles only '*Scutellum*' *estonicum* (Schmidt 1894, p. 36, pl. 3, figs. 1–7), from the Upper Silurian (zone H) of Estonia. From Schmidt's illustration of the cranidium it appears that *M. ataphrus* differs in having a relatively wider (tr.) glabella of which the posterior part decreases more in transverse width forward and the change to expanding in transverse width forward is much more marked. In addition, in '*S*'. *estonicum* the preglabellar furrow is present over a greater proportion of the front of the frontal lobe. However, the lateral glabellar muscle impression 1g of '*S*.' *estonicum* is in a similar position to that of *M. ataphrus*, and this is unlike any other described scutelluid genus. The pygidium figured by Schmidt very much resembles that of *M. ataphrus* differing only in having a relatively longer axis and a median posterior rib which is bifid over only half its length, even in large specimens.

The cranidium figured by Öpik (1937, pl. 5, fig. 2) as '*S*.' *estonicum* differs in some ways from that figured by Schmidt, particularly in the form of the 1g lateral muscle impression which is oval in shape and not situated adjacent to the axial furrow, and in the form of the preglabellar furrow which is only present laterally as it is in *M. ataphrus*. In addition, the frontal lobe of Öpik's specimen (which is from the Adavere-Stufe, Llandovery, of Estonia) expands rather more forward than that in Schmidt's material, the posterior part of the glabella is parallel-sided, and the palpebral lobe more posteriorly placed as compared with *M. ataphrus*. It therefore seems likely that '*S*.' *estonicum* of Öpik is different from the species described by Schmidt.

Bearing in mind the form of the preglabellar furrow of '*S*.' *estonicum* in Schmidt's figure, the species is referred, with some doubt, to the new genus *Meroperix*.

Subfamily GOLDILLAENINAE Balashova 1959

Discussion. At several times in the Lower Palaeozoic trilobite record, there was a tendency for a general smoothing of the dorsal exoskeleton by the effacing of furrows.

The classification of forms with smooth exoskeletons is difficult and becomes more difficult the farther the trend progresses. The difficulty can also be magnified when the effacing of furrows occurs in groups of trilobites which are closely related.

Thus, in the case of the smooth illaenids and scutelluids which are thought to be closely related (Whittington 1963, p. 83), such a difficult problem of classification is encountered. However, the removal by Balashova of *Goldillaenus* Schindewolf 1924 and similar forms from the Illaenidae seems to be justified. In *Goldillaenus*, *Illaenoides* Weller 1907, and *Ptilillaenus* Lu 1962, the cranidium is unlike that of illaenids in being longer (sag.) than wide, and in having relatively distinct axial furrows which are scutelluid in form, curving concavely forward and outward to reach or almost reach the anterior part of the lateral border furrow. The erection of a new subfamily to receive these forms might be considered premature as little is known of the goldillaenid rostral plate and hypostome, but the taxon is accepted here for it is useful in delimiting the smooth scutelluids from the majority of the Scutelluidae. *Goldillaenoides* Balashova 1959, here considered a scutelluinid, is intermediate in morphology between *Goldillaenus* and *Meroperix* gen. nov.

Genus and species indet. 1

Plate 60, figs. 13–15

Material. Loc. 1419–MMH 11339 (free check); loc. 1510–MMH 11340–1 (cranidia).

Description. Cranidium moderately convex; axial furrow confluent with posterior border furrow behind, curving round through an arc of 90°. Axial furrow runs a little obliquely out from the exsagittal direction, and is almost straight, but with two flexures concave outward in its course, three quarters way from posterior margin becoming very indistinct (especially in larger specimen) and turning outward and widening, and finally running transversely as a broad shallow furrow at the anterolateral margin of the cranidium. No preglabellar furrow is present. The posterior of the two flexures in the course of the axial furrow is caused by a raised muscle impression placed adjacent to the axial furrow on the fixed cheek. No muscle impressions are visible on the glabella. Frontal lobe of glabella near the anterior margin with a few fine terrace lines which are regular and parallel anteriorly, but posterior to the first few break up and become less regular. External surface of cranidium covered with indistinct pits.

Palpebral lobe about as long (exs.) as lateral muscle impression, placed about half the width of the posterior part of the glabella away from the axial furrow, and its own length from the posterior of the cranidium. Anterior branch of facial suture running in a gentle sigmoidal curve, almost exsagittally, first concave outward then inward across anterolateral border to the anterior margin; posterior branch very short, running obliquely outward and back.

Free cheek convex (Pl. 60, fig. 13). Visual surface inflated, bearing about 25 files of lenses on the half preserved, about 16 lenses high at the maximum. Lateral border narrow anteriorly, here bearing 4–5 fine, closely spaced terrace lines, the border narrowing and dying out toward genal angle. Posterior margin concave backward, this margin and the lateral margin at about 60° to one another, forming a blunt genal angle. External surface of free cheek excluding lateral border covered with indistinct pits; at inner posterior corner of free cheek, a few weak fragmented terrace lines are situated.

Discussion. The course of the axial furrow on the cranidia and the character of the fixigenal muscle impression lead to the conclusion that the species represented by these two cranidia and the free cheek is a goldillaenid. No other parts of the exoskeleton have been found. The characters displayed by this small amount of material, however, show that it cannot be placed in a known genus.

Genus and species indet. 2.

Plate 62, figs. 10–14

Figured material. Loc. 1418–MMH 11366 (pygidium); Loc. 1510–MMH 11370 (pygidium); Loc. 1511–MMH 11368 (cranidium), 11367 (free cheek), 11369 (pygidium).

Additional material. Loc. 1511–1 pygidium.

Description. Cranidium moderately convex. Glabella wide, posterior two thirds narrowing (tr.) forward here forming about two thirds the width of the cranidium, the anterior third rapidly widening. Axial furrow confluent with posterior border furrow behind, distinct over posterior two thirds of cranidium, but where the glabella widens, shallowing and dying out before the antero-lateral margin is reached. One third way from the posterior of the cranidium an oval muscle impression is placed on the fixed cheek adjacent to the axial furrow. Palpebral lobe about as long as this fixigenal muscle impression placed close to glabella and half way along cranidium in dorsal view. Anterior branch of facial suture curving outward parallel to axial furrow, posterior branch running a little obliquely adaxially in a very gentle sigmoidal curve over five-sixths of its course, over the posterior part running strongly obliquely outward. Surface of cranidium with many small, closely spaced pits. Lateral to frontal lobe anteriorly, a very narrow anterior border and border furrow is present, the border with a few parallel terrace lines; such lines are also present on the doublure anteriorly.

A fragmentary free cheek attributed to this species shows that the genal angle is rounded (Pl. 62, fig. 11). Lateral border gently convex with many subparallel terrace lines which are most regular and closely spaced near the margin; these lines continue as broken subparallel lines over the part of the free cheek between the indistinct border furrow and the eye. Dorsal surface with closely spaced small shallow pits as on other parts of exoskeleton, these pits a little less common on the free cheek where the terrace lines are best developed. Doublure wide, under the lateral margin rounded convex in shape, toward genal angle widening. Terrace lines present and becoming more widely spaced where the doublure widens, and finally dying out at a submarginal curved ridge which bounds the vincular furrow, the doublure in this furrow being smooth.

Pygidium attributed to same species convex, rounded triangular in shape, lacking any sign of axial or pleural furrows, but with a narrow slightly concave area parallel to the margin all round which is better displayed on larger specimens. Middle third of anterior margin with a shallow depression parallel to the margin on the inner surface of the exoskeleton. Anterolaterally, articulating facets are placed which extend the pygidial margin a little forward and laterally, and which bear fine terrace lines, the posterior of which bend increasingly back and form a very narrow terraced border similar to that described in the cranidium: this border runs completely round the lateral and posterior margins of the pygidium. Internal and external moulds with shallow closely spaced pits as on the cranidium, these pits larger towards the anterior and middle of the pygidium, a pair of oval areas are situated near anterior margin which bear very few pits (Pl. 62, fig. 14). Doublure of pygidium with convex ventral surface bearing terrace lines parallel to the margin, sagittally one third the length of the pygidium, narrowing to two thirds this width at the anterolateral corner.

Discussion. The course of the axial furrow and the character of the muscle impression again indicate the relationship of this species to the Goldillaeninae. The similarity of the narrow border with terrace lines, and the surface sculpture of cranidium and pygidium suggest that these parts may be attributed to the same species. The pit sculpture is best developed on the largest pygidium, and least distinct on the smallest. The form of the axial furrow, the position of the palpebral lobe, and the convexity of the cranidium, serve to distinguish this cranidium from goldillaenid gen. et sp. indet. 1. Like the latter material, it is not possible to place gen. et sp. indet. 2 in a known genus, and it is thought that it represents a second new, but undescribed goldillaenid.

Family ILLAENIDAE Hawle and Corda 1847
Subfamily ILLAENINAE Hawle and Corda 1847
Genus STENOPAREIA Holm 1886

Type species. Illaenus linnarssonii Holm 1882 from the Ashgill (Boda Limestone) of Dalarna, Sweden.

Stenopareia sp.

Plate 61, figs. 13–15

Figured material. Loc. 1420–MMH 11356 (cranidium); Loc. 1510–MMH 11355 (cranidium), 11354 (hypostome).

Additional material. Loc. 1421–1 cranidium; Loc. 1422–1 cranidium; Loc. 1510–1 cephalon.

Description. Profile of cranidium in sagittal line curving evenly through a quarter of a circle. Glabella at posterior margin more than half the width of the cranidium, defined by broad furrows which converge forward to a point opposite the middle of the palpebral lobe, here the furrows becoming oval depressed areas; these areas with their long axes slightly divergent anteriorly. The oval depressed area is about one third as long as the part of the axial furrow posterior to it; axial furrow continuing forward of the depressed area as a divergent, short and very shallow furrow about one eighth the length of the whole furrow. Especially in a medium sized cranidium (Pl. 61, fig. 14*b*), the ventral surface of

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EXPLANATION OF PLATE 61

?*Dicranopeltis*? sp.

Fig. 1*a–b*. MMH 11342, fragmentary cranidium, loc. 1510. *a*, occipital view, ×5; *b*, oblique anterior view, ×4.

Otarion sp.

Fig. 2*a–b*. MMH 11343, fragmentary cranidium, loc. 1418, ×6. *a*, dorsal and *b*, lateral views.

Fig. 3. MMH 11344, free cheek, lateral view, loc. 1419, ×5.

Cyphoproetus sp.

Fig. 4*a–b*. MMH 11345, cranidium, loc. 1418, ×6. *a*, dorsal and *b*, oblique posterior views.

Warburgella sp.

Fig. 5*a–c*. MMH 11346, cephalon, loc. 1511. *a*, oblique anterolateral view, ×8; *b*, dorsal view, ×8; *c*, oblique dorsal view showing coarse surface sculpture interrupted by weak 2S and 3S furrows, sagittal furrow in preglabellar field, anterior branch of facial suture with tropidium discontinuous and displaced across it, and the banded border, ×12.

Fig. 8. MMH 11349, free cheek, dorsal view, loc. 1418, ×8.

Fig. 9. MMH 11350, free cheek, dorsal view, loc. 1418, ×8.

Fig. 10. MMH 11351, cranidium, dorsal view, loc. 1421, ×6.

Warburgella? sp.

Fig. 6*a–b*. MMH 11347, pygidium, loc. 1419, ×4. *a*, dorsal and *b*, lateral views.

Fig. 7. MMH 11348, pygidium, dorsal view, loc. 1511, ×4.

Scharyia sp.

Fig. 11. MMH 11352, pygidium, dorsal view, loc. 1421, ×10.

Scharyia? sp.

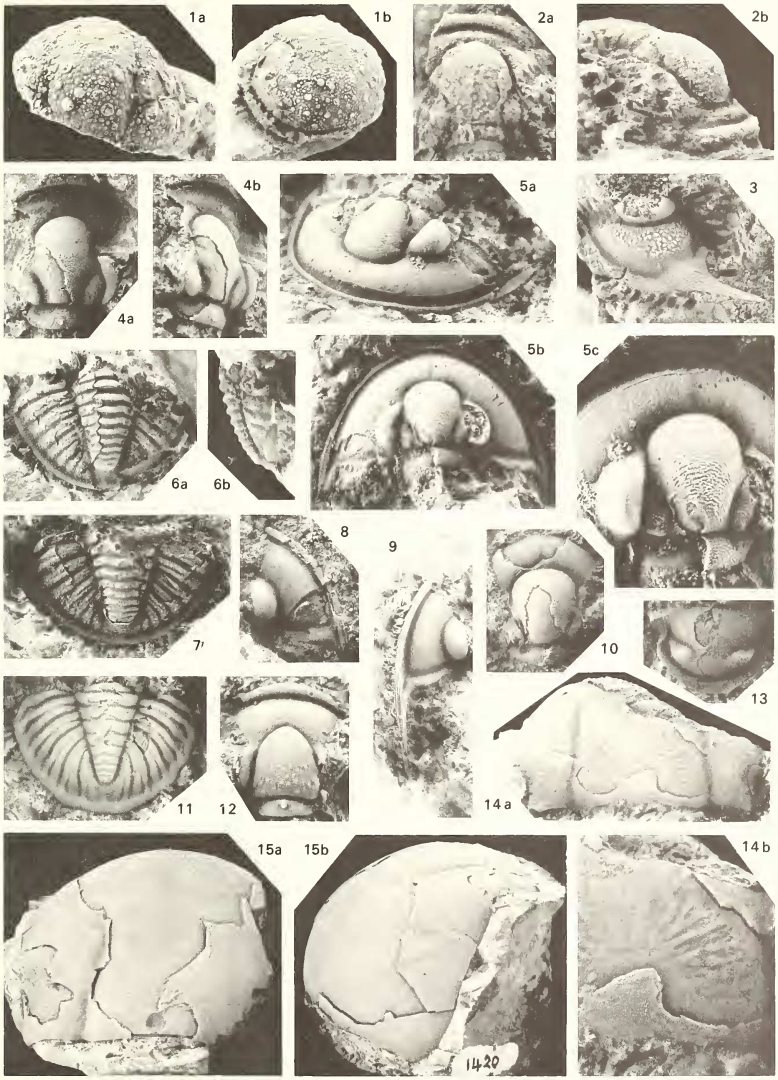
Fig. 12. MMH 11353, cranidium, dorsal view, loc, 1418, ×9.

Stenopareia sp.

Fig. 13. MMH 11354, hypostome, ventral view, loc. 1510, ×5.

Fig. 14*a–b*, MMH 11355, cranidium, palpebral views, loc. 1510. *a*, ×2 and *b*, ×5 showing caecal markings on internal mould of glabella.

Fig. 15*a–b*, MMH 11356, cranidium, loc. 1420, ×1. *a*, occipital and *b*, oblique anterolateral view.



LANE, Silurian trilobites

the exoskeleton of the glabella has a fan-like arrangement of shallow radiating ridges and furrows which centre on the sagittal line near the posterior margin of the cranidium.

Palpebral lobe small, exsagittally arched, placed about twice its own length from the posterior margin of the cranidium. Facial suture in dorsal view an almost straight exsagittally directed line which curves outward a little near the posterior margin, in lateral view the posterior branch sloping gently downward away from the palpebral lobe, the anterior branch running almost vertically down so that the two branches in this view are at nearly 90° to one another. The anterior branch of the facial suture in anterior view curves inward toward the anterior margin, near which are subparallel terrace lines which are shallow furrows with a rectangular section.

Hypostome wider (tr.) then long (sag.) in ventral view (Pl. 61, fig. 13). Middle body with sigmoidally curved middle furrows which reach about 1/3 way across; anterior lobe approaching twice as long (sag.) as the posterior. Posterior lobe immediately behind middle furrows inflated into maculae which bear large distinct regularly arranged tubercles. Anterior wings wide: lateral-posterior border furrow distinct, lateral-posterior border flat ventrally, with a slight widening posteromedially where the posterior outline is angulate. Surface of hypostome except in furrows and on maculae with fine, raised terrace lines, which on the borders are subparallel to the margin, and on the middle body subparallel and curved, convex backward.

Discussion. A small cephalon which probably belongs to this species has also been found. It is semicircular in outline and measures 8 mm transversely, and 4 mm sagittally. It differs from larger specimens in being less convex, having less distinct axial furrows, a relatively much larger eye, and terrace lines are seen over a much greater proportion of the surface. The cephalic doublure is also seen in this small specimen, it is widest sagittally, narrows markedly laterally, and bears very distinct, subparallel terrace lines. On this small cephalon the courses of the ventral sutures cannot be seen.

The amount of available material of this species is insufficient to enable a valid comparison with described species of *Stenopareia*. In only one other species of the genus known to the author have caecal markings on the glabella been described. *S. oviformis* (Warburg 1925; see Jaanusson 1954, p. 570, pl. 2, fig. 7) has four paired areas of glabellar caecal markings, the anterior pair the smallest and placed close to the anterior margin of the cranidium, the posterior pair largest, but of smaller relative extent than the area seen in *Stenopareia* sp. described above. In addition, the areas with caecal markings are visible on the dorsal surface of the exoskeleton in *S. oviformis* whereas no trace of markings has been observed on the dorsal surface of the exoskeleton of *Stenopareia* sp.

Family PROETIDAE Salter 1864
Subfamily PROETINAE Salter 1864
Genus PROETUS Steininger 1831
Subgenus CYPHOPROETUS Kegel 1927

Type species. Cyphaspis depressa Barrande 1846 from the Silurian of Czechoslovakia.

Cyphoproetus sp.

Plate. 61, fig. 4

Material. MMH 11345, cranidium (Loc. 1418).

Description. Glabella equally wide across occipital ring and 1L lobes, narrowing in front of this and then widening a little anteriorly, rounded in front. Occipital ring wide and bearing a median tubercle which is placed nearer the posterior margin than the occipital furrow. Occipital furrow narrow and deep. 1S furrow originates near axial furrow half way along the glabella as an indistinct depression,

which runs obliquely back and deepens behind the 1L lobe, and before reaching occipital furrow widens and shallows to isolate ovate 1L lobe which is twice as long (sag.) as wide. Surface of glabella finely granulate. Axial furrow distinct, widening to form preglabellar furrow anteriorly.

Palpebral lobe convex, placed adjacent to axial furrow, extending from occipital furrow to anterior to the origin of the 1S furrow. Posterior branch of facial suture not seen, anterior branch from anterior of palpebral lobe curving convex adaxially parallel to the narrowest part of the glabella, then running in almost a straight line obliquely out, finally curving adaxially across anterior border furrow and border. Anterior border strongly raised; between this and the glabella is a wide parallel-sided depression bearing scattered granulations which is bounded internally by a further furrow and is sagittally confluent with the preglabellar furrow; between the anterolateral part of the axial furrow and the bounding furrow is a very gently convex triangular area of the cranidium.

Discussion. The width of the anterior border furrow of this cranidium coupled with the strongly raised anterior border and the lack of a tropidium indicate that it probably belongs to *Cyphoproetus*.

Subfamily PROETIDELLINAE Hupé 1953
Genus WARBURGELLA Reed 1931

Type species. Asaphus stokesii Murchison 1839 from the Wenlock of England.

Warburgella sp.

Plate 61, figs. 5, 8–10

Material. Loc. 1418–MMH 11349–50 (free cheeks); Loc. 1421–MMH 11351 (cranidium); Loc. 1511–MMH 11346 (cephalon).

Description. Cephalon almost semicircular in outline, anteromedially with a very slight rounded angulation. Glabella widest across convex occipital ring which bears a median tubercle, in front of the narrow occipital furrow subquadrate in outline, slightly narrowing forward. 1S furrows very oblique, originating near axial furrow almost half way along preoccipital part of glabella, becoming very deep half way along their course and reaching the occipital furrow. 1L lobe triangular, longer (exs.) than wide. Surface of glabella with coarse linear corrugations arranged in convex forward transverse arcs, these corrugations absent in three paired areas, the posterior running transversely from anterior of 1S, the anterior two considered to represent 2S and 3S, close together and originating near axial furrow opposite anterior of palpebral lobe.

Eye large, bulbous, crescentic in plan, and placed adjacent to the axial furrow; sagittally it measures about half the total length of the glabella. Anterior branch of facial suture running from anterior of palpebral lobe obliquely outward, anteriorly curving adaxially; posterior branch very short, running very obliquely out and cutting posterior margin half way from axial furrow to genal angle. Posterior border of cheek widening from axial furrow, here directed obliquely back about 1/3 way to lateral margin becoming transverse and from here of constant width. Anterior and lateral parts of cheek with a roll-like border of near constant width which bears a series of oblique, subparallel raised terrace lines which gives to the border the appearance of a rope. Inside the border there is a distinct furrow, of which the inner margin rises steeply to the remaining part of the cheek, which is convex. On the convex preglabellar field, which sagittally measures half the sagittal length of the preoccipital part of the glabella, there is a shallow furrow in the sagittal line which is present on both external and internal moulds. Parallel to the border furrow and on the inner margin of it, there is a thread-like tropidium, which is discontinuous and displaced across the anterior branch of the facial suture, so that it is set a little nearer the glabella on the cranidium; here it is also arched back a little medially where it crosses the sagittal furrow. Genal angle bears a spine about as long as the sagittal length of the glabella, this spine bearing a few raised ribs.

Discussion. These specimens have been placed in *Warburgella* because of the deep 1S furrows of the glabella, and the convex preglabellar field. They differ from described

species of that genus in having a relatively wide preglabellar field which bears a sagittal furrow, and in possessing a tropidium.

Warburgella? sp.

Plate 61, figs. 6–7

Material. Loc. 1419–MMH 11347 (pygidium); Loc. 1511–MMH 11348 (pygidium).

Description. Pygidium semicircular in outline behind, almost twice as wide (tr.) as long (sag.). Axis very convex as compared to pleural portions, decreasing in transverse width back, not reaching posterior border furrow, and bearing 10 rings. Articulating half ring very narrow (sag. and exs.). Inter-ring furrows of the axis about half as wide (sag. and exs.) as rings, from the axial furrow running slightly obliquely forward, but curved convex backward at sagittal line. Pleural portions with an anterior unfurrowed and 7 furrowed ribs which are almost straight and increasingly posteriorly directed. A ninth pair of ribs is also present posteriorly, indistinctly defined. Between the posterior pair of ribs and behind the axis there is a small, gently convex area. Interpleural furrows distinct, widening abaxially; ribs and furrows ending at concave posterolateral furrow outside which there is a convex border which is narrow. Pleural ribs bearing closely packed coarse granules which are present but less distinct on the axis and the posterolateral border furrow. Doublure narrow where it is seen posteriorly, with very little ventral convexity, bearing 5 subparallel terrace lines.

Discussion. The general features displayed by these two pygidia are thought to be most closely similar to the pygidia of species of *Warburgella*, but because of the difficulty of assigning isolated proetid pygidia they are only referred to that genus with doubt. The surface sculpture of these pygidia is so different from that of the cephalon described above as *Warburgella* sp., that it is probable that they do not belong together.

Family OTARIONIDAE Richter and Richter 1926
Genus OTARION Zenker 1833

Type species. Otarion diffractum Zenker 1833 from the Silurian of Czechoslovakia.

Otarion sp.

Plate 61, figs. 2–3

Figured material. Loc. 1418–MMH 11343 (cranidium); Loc. 1419–MMH 11344 (free cheek).

Additional material. Loc. 1511–1 cranidium.

Description. Glabella narrowing forward, very convex, with isolated 1L lobe. Axial furrow distinct. Preglabellar furrow short (sag.), and convex, falling into deep anterior border furrow; anterior border convex. Anterior branch of facial suture running in a broad curve from just anterior to the origin of the 1S furrow, first obliquely out and then adaxially across the anterior border furrow and border. Surface of cranidium, except in furrows, with large, closely spaced granules.

Free cheek associated with cranidia has a lateral border which widens from anterior to genal angle, and bears 4–5 subparallel raised terrace lines. Lateral border furrow deeper and narrower anteriorly shallowing posteriorly and separated from posterior border furrow by a raised convexity at the base of the genal spine, upon which 8–9 raised terrace lines originate and run down the length of the genal spine. Lateral margin incurved slightly at proximal end of genal spine. In an area extending from close to the anterior of the eye, which widens and runs round toward the posterior border furrow, large, closely spaced granules are situated. Eye inflated so that the visual surface is very convex, and beneath it there is a distinct furrow.

Discussion. The short, convex preglabellar field, isolated 1L lobes and coarse sculpture are all characteristic of species of *Otarion*. The isolated free cheek has been associated

with the fragmentary cranidia because its coarse sculpture is similar to that of the cranidia referred to *Otarion* and the incurved margin at the proximal end of the genal spine is characteristic of this genus.

PROETACEA *incertae sedis*

Genus SCHARYIA Přibyl 1946

Type species. Proetus micropygus Hawle and Corda 1847 from the Silurian of Czechoslovakia.

Scharyia sp.

Plate 61, fig. 11

Material. MMH 11352, pygidium (Loc. 1421).

Description. Pygidium broadly rounded, ratio of sagittal length to maximum transverse width 3:4. Axis straight sided, conical, of low convexity, with 9 rings: anterior 5 inter-ring furrows less distinct sagittally than adjacent to axial furrow. Axial furrow distinct, widening behind the axis. Pleural portions convex, bearing a convex anterior pleural band, behind which there are 5 furrowed ribs which curve backward, the rib furrows increasing in depth toward the margin. Interpleural furrows deep. Posteriorly there is a border furrow which is increasingly strongly interrupted by the furrowed ribs anteriorly; anterior three pairs of ribs confluent with lateral border. Anterior parts of furrowed ribs each bears, adjacent to the axial furrow, a small, distinct granule.

Discussion. The conical axis, deep interpleural furrows, distinct border and posterior border furrow, and the small granules placed on the anterior part of furrowed pleural ribs indicate that this small pygidium belongs to *Scharyia.*

Scharyia? sp.

Plate 61, fig. 12

Material. MMH 11353 fragmentary cranidium (Loc. 1418).

Description. Glabella of low convexity, rounded triangular in outline, surrounded by a distinct axial furrow. Occipital ring convex (tr. and sag.) medially bearing a large tubercle which is placed nearer to the very deep occipital furrow than the posterior margin. Preglabellar field convex, falling anteriorly into a very deep anterior border furrow. Anterior border convex, bearing 4 raised terrace lines which are parallel to the anterior margin. Palpebral lobe narrow, placed adjacent to the axial furrow, almost as high as the highest point of the glabella, extending from near occipital furrow to about two-thirds way along preoccipital part of glabella. Posterior branch of facial suture not seen, anterior branch curving gently out to anterior border furrow, curving toward sagittal line across this and the anterior border. Surface of cranidium except anterior border and border furrow, and axial and occipital furrows with regularly scattered granules which are quite large and low.

Discussion. As the posterior branch of the facial suture is not preserved it is not possible to be certain that this small cranidium belongs to *Scharyia.* The form of the cranidium in general, however, is similar to *Scharyia,* and although the glabella is not furrowed as it is in the type species there is a granule-free patch on the surface of the postero-lateral parts of the glabella which could indicate a 1S furrow. The coarse granules of this cranidium are a feature not seen in other species of *Scharyia,* except *S. nympha* Chlupáč (1971, p. 172, Pl. 23, figs. 1–6; text-fig. 5) from the lower part of the Pridoli Formation (Upper Silurian) of Zadni Kopanina, Czechoslovakia. *S. nympha* differs from the cranidium described above as *Scharyia* sp. in having a much narrower (tr.)

glabella, longer (sag.) pre-glabellar field and anterior border, and eyes placed at a much greater distance from the axial furrow.

Family HARPIDAE Hawle and Corda 1847
Genus SELENOHARPES Whittington 1950

Type species. Harpes (*Eoharpes*) *youngi* Reed 1914, from the Lower Caradoc of the Girvan area, south Scotland.

Selenoharpes loma sp. nov.

Plate 62, figs. 1–9

Derivation of name. loma (Gr.) = fringe or brim.

Holotype. MMH 11357 (Pl. 62, figs. 1*a–b*) cephalon (Loc. 1418). Length (sag.) 14·0 mm; maximum width (tr.) 22·0 mm (est.).

Other figured material. Loc. 1418–MMH 11359–60, 11365 (cephala), 11361 (hypostome); Loc. 1419–MMH 11358 (cephalon); Loc. 1510–MMH 11362–4 (cephala).

Additional material. Loc. 1418–2 cephala; Loc. 1419–2 cephala; Loc. 1420–1 cephalon; Loc. 1421–1 cephalon; Loc. 1422–1 cephalon; Loc. 1510–3 cephala; Loc. 1511–2 cephala.

Diagnosis. Selenoharpes with very convex glabella whose basal lobes protrude only slightly from its straight sides. Ala well defined, convex, standing above cheek lobe and well above posterior border furrow posteriorly. Preglabellar field very narrow (sag.); cheek roll medially with distinct convex swelling. Brim concave, widest anteriorly. Genal caecae indistinct on cheek lobe, very distinct on cheek roll and brim, reaching external rim; minute pits between caeca about 16 in number in the width of the cheek roll anteriorly, and about 40 in the brim in the same region.

Description. Cephalon oval in outline, maximum width (tr.) in line with about mid length of glabella, length (sag.) a little greater than that of prolongation (exs.), height a little more than one third the maximum width. Glabella very convex, tapering gently forward, sagittally a little less than half the length of cephalon; occipital ring narrower exsagittally than sagittally, with posterior margin curved convex backward and a median occipital tubercle adjacent to occipital furrow, this furrow deeper distally in internal moulds. Basal glabellar furrow shallow on external moulds, originating in axial furrow about two-fifths way from the posterior of the glabella, and curving convex backward across glabella reaching less than one-third way across in dorsal view due to high convexity of glabella; basal glabellar lobe subtriangular, gently convex. Convex cheek lobe slopes distally, having between eye lobe and glabella a broad shallow depression; posterior border furrow wide and shallow, posterior border narrow and convex. Axial furrow narrow and shallow. Preglabellar field narrow (sag.). Eye lobe situated well forward opposite anterior part of glabella, and bearing a single lens (Pl. 62, fig. 2); eye ridge indistinct, traversing shallow depression between eye lobe and glabella in a line running a little obliquely back adaxially. Ala about one third length (sag.) of glabella, convex, standing well above posterior border furrow posteriorly, laterally and anteriorly defined by a shallow furrow. Convexity of cheek lobe continued by cheek roll, anterior to glabella this having a sagittally elongated swelling which bows the girder forward at this point, cheek roll decreasing in width posterolaterally. Brim concave, but adjacent to girder anteriorly and anterolaterally with a slight convexity; prominent external rim narrow and convex dorsally. Prolongation less concave than brim, abaxially sloping downward with prominent external and internal rim. Girder a distinct smooth plane band which curves round to meet internal rim on prolongation a little distance behind posterior border, with large pits adjacent to it on both sides. Cheek lobe bearing indistinct ridge-like caecae anterior to ala, which on the cheek roll become more distinct and continuous across girder and brim to external rim. Cheek ridge indistinct and seen only adjacent to eye lobe, running obliquely back abaxially. Between genal caecae are minute

pits, 15–17 in the width of the cheek roll anteriorly and anterolaterally, about 40 in the brim in the same region. On the anterior internal part of the prolongation the cheek roll has large pits and indistinct caecae.

Hypostome sagittally elongate. Middle body decreasing only a little in transverse width from anterior to posterior, very convex, reaching maximum height at about half way back. Middle furrows oblique, wide and shallow, reaching about one-third way across middle body, marking off a posterior lobe which is about one-sixth the whole length. Border furrows only distinct laterally, posterior to the rounded, wide anterior wings; adjacent to lateral border furrow, border very narrow. Border and border furrows not present anteriorly or posteriorly.

Discussion. Small specimens of *S. loma* show some differences in overall dimensions as compared to larger specimens, and these are as follows. In the small specimens the brim is relatively wider anteriorly than laterally and bears pits, caecae only being visible adjacent to the girder; the glabella tapers forward less, has relatively smaller basal lobes and more distinct basal glabellar furrows.

Other species of *Selenoharpes* are distinguished from *S. loma* in possessing the following morphological features. *S. youngi* (Reed 1914) from the Lower Caradocian of Balclatchie, Girvan has a girder which reaches further back along prolongation which itself slopes steeply outwards, the cheek roll has no anterior swelling, and the caecae do not reach the rim of the brim which is wider laterally than anteriorly. *S. excavatus* (Linnarsson 1875) from the early Lower Ordovician of Nerike province, Sweden has the cheek roll and preglabellar field of equal sagittal width, a transverse eye ridge, alae convex but depressed, cheek lobes with distinct caecal ridges and more and smaller pits on the cheek roll and brim. *S. concavus* (Thorslund 1940) from the Middle Ordovician of the central Lockne area, Sweden has large eye lobes, distinct caecae on cheek lobes, indistinct on brim, basal glabellar lobes which project from the sides of the glabella,

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EXPLANATION OF PLATE 62

Selenoharpes loma sp. nov.

Fig. 1*a–b*. MMH 11357, holotype cephalon, dorsal view, loc. 1418, ×3. *a*, view showing dorsal surface of lower lamella; *b*, dorsal view of latex cast showing parts of upper lamella.

Fig. 2. MMH 11358, cephalon, oblique view, loc. 1419, ×9, showing palpebral lobe and 'lidded' single facet, weak cheek furrow, pitting of cheek and part of the cheek roll.

Fig. 3. MMH 11359, small cephalon, dorsal view, loc. 1418, ×5.

Fig. 4. MMH 11360, fragmentary cephalon, dorsal view, loc. 1418, ×3.

Fig. 5. MMH 11361, hypostome, ventral view, loc. 1418, ×7.

Fig. 6. MMH 11362, cephalon, oblique lateral view, loc. 1510, ×3, showing dorsal surface of upper lamella.

Fig. 7. MMH 11363, small cephalon, dorsal view, loc. 1510, ×6.

Fig. 8. MMH 11364, cephalon, latex cast showing dorsal view of parts of both upper and lower lamellae, loc. 1510, ×3.

Fig. 9. MMH 11365, small cephalon, dorsal view, loc. 1418, ×4.

Goldillaenid *gen.* et *sp. indet.* 2.

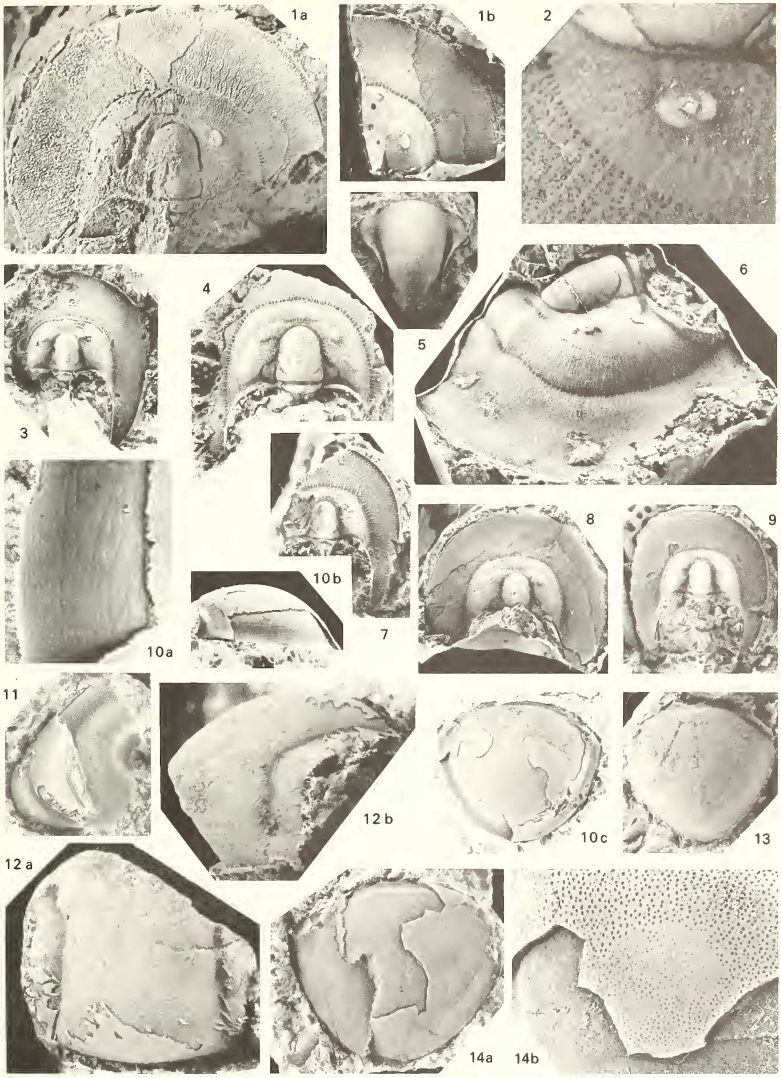
Fig. 10*a–c*. MMH 11366, pygidium, loc. 1418. *a*, enlarged lateral view showing terracing of doublure, ×6; *b*, lateral view, ×2; *c*, dorsal view, ×2.

Fig. 11. MMH 11367, fragmentary free cheek, ventral view showing sculpture of dorsal and doublural surfaces, and vincular furrow, loc. 1511, ×3.

Fig. 12*a–b*. MMH 11368, cranidium, loc. 1511, ×3. *a*, palpebral and *b*, anterior oblique views.

Fig. 13. MMH 11369, small pygidium, dorsal view, loc. 1511, ×3.

Fig. 14*a–b*. MMH 11370, pygidium, loc. 1510. *a*, dorsal view, ×2; *b*, dorsal view showing surface sculpture interrupted by oval relatively smooth area, ×6.



LANE, Silurian trilobites

curved prolongations and width of brim greater laterally than anteriorly *S. vitilis* Whittington 1963 from the Middle Ordovician of Lower Head, Western Newfoundland has smaller basal glabellar lobes, depressed alae, no anterior swelling of the cheek roll, a distinct genal ridge, fewer pits in brim, distinct caecae on cheek lobes and a more curved inner rim of the prolongation. *S. fragilis* (Raymond 1925) from the Cow Head Group of Stearing Island has the basal lobe protruding from the general outline of the glabella, no anterior swelling of the cheek roll, and in lateral view has a less steep, less convex outline of preglabellar field, cheek roll and brim. *S. willsi* Whittington 1950 from the Upper Llandovery of North Wales and Yorkshire has a relatively longer glabella rectangular in outline, small eye lobes, faint eye ridges 'running directly inwards', depressed alae, girder on upper lamella ridgelike, brim narrower and flat with caecae faintly marked, and fewer pits. *S. judex* (Marr and Nicholson 1888) from the Middle to Upper Llandovery of the Lake District, northern England has more pronounced caecae on the cheek lobes and a row of coarser pits externally on the brim; in addition to Whittington 1950, p. 48, the brim is convex dorsally, the anterior swelling in the cheek roll is less pronounced than in *S. loma* and the eye lobe is one-third way from the anterior of the glabella. *S. consuetus* (Billings 1866) from the uppermost Llandovery of Southwest Point, Anticosti Island, Quebec is known from a single cephalon, which, as compared to *S. loma* is relatively wider, has larger and more laterally pronounced basal lateral glabellar lobes, the occipital furrow curves forward medially, the girder meets the internal rim of the prolongation more posteriorly, and the upper external rim is wider and more convex. *S. sinensis* (Grabau 1925; Lu 1962, p. 171, pl. 1, figs. 7–8) from the Middle Silurian of Hupeh, China has a 1S glabellar furrow which originates near the axial furrow half way along the glabella, a transverse eye ridge, a curved cheek ridge and small depressed alae. In addition the girder is ridgelike and reaches the internal rim of the prolongation just behind the posterior border of the cephalon; the brim is flat and has 30 pits in lines in its width between the caecae, and there are about 20 pits in lines on the width of the cheek roll. '*Harpes*' *telleri* Weller 1907 from the Racine Dolomite (late Wenlock or early Ludlow age) of Wisconsin is described from poorly preserved material. From the overall proportions, the species probably belongs to *Selenoharpes*, but in the absence of any details of morphology owing to the poor preservation, its generic position is not certain, and its relation to other *Selenoharpes* species cannot be assessed.

Family CHEIRURIDAE Hawle and Corda 1847
Subfamily CHEIRURINAE Hawle and Corda 1847
Genus CHIOZOON gen. nov.

Type species. Chiozoon cowiei sp. nov.

Derivation of name. Contraction of *chion* (Gr). = snow+*zoon* (Gr.) = animal, referring to the locality from which the fauna was collected.

Diagnosis. Glabella narrow, almost straight sided, expanding forward. Palpebral lobe small, extending from opposite anterior to opposite posterior of 3L. Pygidium with three pairs of obliquely furrowed pleural ridges; three pairs of spines, and a terminal spine of about equal size, the anterior pair curved back, posterior pairs less curved and more posteriorly directed; terminal spine spatulate.

Discussion. Chiozoon gen. nov. is readily distinguished from all other cheirurinids by its narrow, almost straight-sided glabella, position of the eye, and the seven subequally sized spines of the pygidium. This genus is referred to by Lane (1971, p. 77, text-fig. 11) as the undescribed new genus from Greenland, and further discussion of its relationships to, and differences from other cheirurinids will be found there.

Chiozoon cowiei gen. et sp. nov.

Plate 63, figs. 1–12

Derivation of name. In recognition of one of the collectors of the fauna, Dr. J. W. Cowie.

Holotype. MMH 11381 (Pl. 63, figs. 11*a*, *b*), pygidium (Loc. 1418). Length (sag.) 21·0 mm; maximum width (tr.) 36·0 mm (est.).

Other figured material. Loc. 1418–MMH 11372 (glabella), 11380 (pygidium); Loc. 1421–MMH 11378, 11382 (cranidia), 11373, 11376 (hypostomes), 11379 (thoracic segment), 11374 (thoracic pleura); Loc. 1422–MMH 11371 (cephalon); Loc. 1510–MMH 11377 (cranidium), 11375 (hypostome).

Additional material. Loc. 1418–4 cranidia, 3 pygidia; Loc. 1419–1 cranidium; Loc. 1421–2 cranidia, 1 hypostome, 1 thoracic segment, 2 pygidia; Loc. 1422–1 cranidium, 3 thoracic segments; Loc. 1510–2 cranidia, 1 thoracic segment; Loc. 1511–1 thoracic segment, 1 pygidium.

Description. Cephalon about semicircular in outline, frontal lobe of glabella slightly bowing forward the anterior outline. Glabella less than one-third the transverse width of the cephalon at posterior margin, almost straight sided, expanding forwards to frontal lobe which is rounded in front. 3L almost parallel sided, a little wider than 2L (exs.), this in turn a little wider than 1L (exs.). 3S furrows curved, directed obliquely back adaxially and reaching more than one-third way across glabella, 2S a little shorter, straighter and less oblique, 1S oblique, wide and deep abaxially, straight for about one-quarter way across glabella, there shallowing markedly and turning posteriorly, and reaching occipital furrow as an indistinct depression. Occipital ring narrow (exs.), widening mesially where occipital furrow is curved forward. Axial furrow wide and deep from posterior margin of cranidium to opposite 3S where an anterior pit is placed, weakly delimited adjacent to widest part of frontal lobe, continuing anterior to this as shallow and distinct preglabellar furrow which adaxially curves upwards and dies out, not present over median one-quarter to one-fifth of transverse width of frontal lobe in anterior view. Glabella posterior to frontal lobe with sparse granules, frontal lobe granulate.

Cheeks triangular, convex. Posterior border narrow, widening (exs.) about half way from axial furrow to genal angle (in dorsal view), abaxial to articulating flange and fulcral socket carried on posterior margin, convex (exs.); posterior border furrow narrow and distinct; lateral border as narrow as proximal part of posterior border, of constant width, convex, lateral border furrow narrow and

EXPLANATION OF PLATE 63

Chiozoon cowiei gen. et sp. nov.

Fig. 1*a–b*. MMH 11371, cephalon, loc. 1422, ×2. *a*, dorsal and *b*, lateral views.
Fig. 2. MMH 11372, small fragmentary glabella, dorsal view, loc. 1418, ×4.
Fig. 3*a–b*. MMH 11373, hypostome, loc. 1421, ×2. *a*, lateral and *b*, ventral views.
Fig. 4. MMH 11374, thoracic pleura, dorsal view, loc. 1421, ×3.
Fig. 5*a–b*. MMH 11375, fragmentary hypostome, loc. 1510, ×1. *a*, lateral and *b*, ventral views.
Fig. 6. MMH 11376, fragmentary hypostome, ventral view, loc. 1421, ×1.
Fig. 7*a–c*. MMH 11377, small pathological cranidium, loc. 1510, ×3. *a*, lateral, *b*, dorsal and *c*, oblique anterior views.
Fig. 8. MMH 11378, cranidium, dorsal view, loc. 1421, ×1.
Fig. 9. MMH 11379, fragmentary thoracic segment, dorsal view, loc. 1421, ×2.
Fig. 10. MMH 11380, fragmentary pygidium, dorsal view, loc. 1418, ×1½.
Fig. 11*a–b*. MMH 11381, holotype pygidium, dorsal views, loc. 1418. *a*, ×2, *b*, ×3 showing sculpture of posterior spine.
Fig. 12. MMH 11382, cranidium, dorsal view, loc. 1421, ×1.